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## Opinion piece

# Impending conservation crisis for southeast Asian amphibians

**With an understudied amphibian fauna, the highest deforestation rate on the planet and high harvesting pressures, southeast Asian amphibians are facing a conservation crisis. Owing to the overriding threat of habitat loss, the most critical conservation action required is the identification and strict protection of habitat assessed as having high amphibian species diversity and/or representing distinctive regional amphibian faunas. Long-term population monitoring, enhanced survey efforts, collection of basic biological and ecological information, continued taxonomic research and evaluation of the impact of commercial trade for food, medicine and pets are also needed. Strong involvement of regional stakeholders, students and professionals is essential to accomplish these actions.**

**Keywords:** amphibians; Southeast Asia; conservation; habitat loss

Globally, approximately one-third of all amphibian species are threatened with extinction, and almost half are experiencing population declines (Stuart *et al.* 2004). Without documented amphibian population declines, and only recent confirmation of the amphibian disease chytridiomycosis in the region (Kusrini *et al.* 2008), southeast Asian amphibians have slipped under the global conservation community's collective radar. Of 732 scientific articles with the keywords 'amphibian' and 'conservation', only eight referred to southeast Asian countries, compared with 16 for Central American countries, 25 for South American countries and 37 for tropical African countries (ISI Web of Science, 1 May 2009).

Rather than representing a region of relatively low-conservation priority for amphibians, Southeast Asia is in need of a series of immediate amphibian conservation actions. Southeast Asian amphibians are facing a perfect storm of conservation crisis and impending extinction. The combination of an understudied fauna including a large proportion of undiagnosed diversity, the highest deforestation rate on the planet and over-harvesting is driving Southeast Asia towards an amphibian biodiversity crisis. The conservation challenge facing Southeast Asia is further complicated by comparatively limited local scientific capacity and the logistical challenges of developing a conservation strategy across 11 culturally unique and geographically dispersed countries.

Our knowledge of the diversity, distribution and biology of amphibians in Southeast Asia is deficient. Whereas the amphibians of Singapore, Thailand and

the Philippines are perceived by scientists to be reasonably well studied, even basic information on amphibian diversity, distribution and conservation status is limited for most areas, particularly within Myanmar, Laos, Cambodia and Indonesia. Although over 800 amphibian species are known to inhabit Southeast Asia (Frost 2009), new species are being continuously described. For example, 31 per cent of amphibian species known from Vietnam, Laos and Cambodia in 2005 had been described since 1997 (Bain *et al.* 2007).

Almost one-fifth of southeast Asian amphibians are listed as threatened (IUCN 2009). A further 36 per cent are so poorly known that they are listed as data-deficient, 11 per cent higher than the global average (IUCN 2009). The understudied nature of the amphibian fauna suggests that many more species are probably under threat than we can presently detect.

A significant proportion of amphibian diversity in Southeast Asia is likely to be hidden within morphologically cryptic species groups currently treated as a single species (e.g. Bain *et al.* 2003; Stuart *et al.* 2006a; Zheng *et al.* 2008; Che *et al.* 2009). To date, every molecular study examining widespread southeast Asian amphibian species throughout their ranges has revealed unrecognized species diversity. These overlooked, cryptic species have smaller geographical ranges and subsequently higher vulnerability to extinction than the previously recognized, widespread 'species' (Stuart *et al.* 2006a).

Of all the threats facing amphibians in Southeast Asia, habitat loss is foremost. In Southeast Asia, habitat loss is occurring at higher relative rates than other tropical regions (Achard *et al.* 2002), and at its present rate, three-quarters of Southeast Asia's original forests will disappear by 2100, taking with it an estimated 42 per cent of the regions' biodiversity (Sodhi *et al.* 2004). Southeast Asian amphibians are particularly vulnerable to habitat alterations, as the majority appear to require forested environments and/or specific water regimens (Bain & Hurley 2004). Habitat loss poses the greatest threat to restricted-range, endemic amphibians. In Southeast Asia, the critically endangered Indonesian frog *Philautus jacobsoni* may already be extinct owing to the almost complete loss of habitat at its only known locality (Iskandar & Mumpuni 2004). Similarly, the endangered, lungless frog *Barbourula kalimantanensis* from Indonesian Borneo is under immediate threat of extinction owing to impending habitat destruction (Bickford *et al.* 2008). Dozens of range-restricted species in the Philippines occur in such small, isolated habitat fragments that even natural perturbations could threaten them with extinction (Diesmos *et al.* 2002).

A further major threat to the amphibians of Southeast Asia is the over-harvesting of amphibians from the wild to supply the consumption, traditional medicine and pet trades. Although current understanding of the impacts of regional harvesting on amphibian populations is inadequate, there is worrying anecdotal evidence that over-harvesting may be rapidly driving particular amphibian groups towards extinction. Of great concern is the harvesting and trade of southeast Asian salamandrids, particularly within the genera *Paramesotriton* and *Tylototriton*, for use as traditional medicine and to supply the international pet trade. The harvesting of salamandrids for traditional

medicine in Southeast Asia occurs in Laos, Myanmar, Thailand and Vietnam, where most species are sold for relatively low prices (less than US\$1 per animal). By contrast, the international pet trade targets rare or recently described salamandrid species. For example, large sums of money (more than US\$200) are paid in the main destinations of Japan and Europe for the recently described *Paramesotriton laoensis*, which is a range-restricted species endemic to Laos (Stuart *et al.* 2006b). Such high prices may drive the local extirpation of salamandrid populations, and may be of even greater concern than currently thought, given emerging molecular data suggesting currently widespread species of Asian salamandrids represent complexes of more range-restricted species (Weisrock *et al.* 2006). To date, the nature and scale of the trade in salamandrids has been largely unmonitored.

Over-harvesting for human consumption may also be threatening long-lived and large-bodied frogs throughout Southeast Asia. Whereas baseline population data are lacking, anecdotal evidence suggests that some species in the family Dicroglossidae are heavily targeted and suffer population declines as a result. Substantial population declines have been observed in *Limnonectes blythii* in West Sumatra, Indonesia (D. T. Iskandar 2008, personal observation). Similarly, large-sized individuals of some *Limnonectes* and *Quasipaa* species (greater than 20 cm snout-vent length), once common in historic collections, are now noticeably absent from many sites in Indonesia, Malaysia, the Philippines and Thailand (T. Chanard, A. Diesmos, R. Brown, D. T. Iskandar & R. Inger 2008, personal observation).

The pathogen *Batrachochytrium dendrobatidis*, responsible for the amphibian disease chytridiomycosis and implicated in amphibian population declines and extinctions globally, has recently been detected in Indonesia (Kusrini *et al.* 2008) and the Philippines (R. Brown & Vredenburg 2008, unpublished data). However, the pathogen appears to be absent from amphibians surveyed in Thailand and Hong Kong (Rowley *et al.* 2007; McLeod *et al.* 2008), and so far, there is no evidence of enigmatic amphibian population declines occurring in Southeast Asia as has occurred in other regions. Although it is possible that population declines in the region have gone undetected given the paucity of data on amphibian population trends in the region, there is currently no indication of morbidity or mortality associated with infection by *B. dendrobatidis* in southeast Asian amphibians.

Urgent conservation actions are required to conserve southeast Asian amphibian biodiversity. Owing to the overriding threat of habitat loss, the most critical conservation action is the identification, establishment and strict protection of Important Amphibian Areas (IAAs) for Conservation. IAAs are areas that are assessed as having high species diversity and/or as representing distinctive regional amphibian faunas (Brown & Diesmos 2009). It is these areas where conservation efforts and limited resources may best be applied. However, aside from the usual challenges associated with prioritizing, designing, funding and establishing protected areas in a region of the world characterized by developing economies, rampant exploitation of natural resources and unchecked

human population growth, the conservation of IAAs in Southeast Asia is further impeded by three fundamental stumbling blocks. These include: (i) the challenge of analysing, comparing and prioritizing IAAs on the Asian mainland versus the Indo-Malayan island archipelago; (ii) the challenge of coordinating inter-government and conservation agency cooperation and coordination across many political borders; and (iii) major logistical and permitting obstacles to much needed ongoing biodiversity survey work.

Identification of IAAs can only be as reliable (and useful) as the basic survey data that underpin them, and this information is lacking throughout most of Southeast Asia. Intensive survey efforts must be continued, but with greater frequency and geographical spread. Teams should be composed of experienced field biologists, students and trainees and local stakeholders.

Concurrent with increased survey efforts in new sites, the establishment of amphibian population monitoring programmes and the continuation and publication of ongoing monitoring programmes is a priority for the region. Without baseline information on amphibian population abundance and how it changes over time, it will not be possible to detect population declines. Other actions needed include the collection of basic biological and ecological information on the amphibians of the region, and continued taxonomic research to clarify the nature of the regional faunas, with particular reference to uncovering morphologically cryptic species. Evaluation of the impact of commercial food, medicine and pet trades on Asian amphibians is essential, particularly for salamandrids, forest obligates and large-bodied and long-lived frog species, for which anecdotal evidence suggests are most threatened. Increasing public awareness and the continuing production of local language field guides are also essential. Continued efforts to monitor the distribution and impact of infectious diseases including *B. dendrobatidis*, and tailoring amphibian monitoring methods to assess the effects of climate change environmental contaminants, are required in order to initiate adaptive management plans if necessary. Capacity building to train cohorts of young regional scientists is essential to accomplish these actions. Strong involvement of regional students and professionals must be part of amphibian conservation in Southeast Asia, and elsewhere.

At present, captive breeding does not appear to be a priority for amphibian conservation in Southeast Asia, although it may become required if infectious diseases are determined to be responsible for population declines in the field or under future climate scenarios. Investment in captive breeding in the region should be investigated on a case-by-case basis when major loss of habitat is likely to occur for specific range-restricted species.

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- pp. 723–732. Berkeley, CA: University of California Press.
- Che, J., Hu, J.-S., Zhou, W.-W., Murphy, R. W., Papenfuss, T. J., Chen, M.-Y., Rao, D. Q., Li, P.-P. & Zhang, Y.-P. 2009 Phylogeny of the Asian spiny frog tribe Paini (Family Dicoglossidae) sensu Dubois. *Mol. Phylogenet. Evol.* **50**, 59–73. (doi:10.1016/j.ympev.2008.10.007)
- Diesmos, A. C., Brown, R. M., Alcalá, A. C., Sison, R. V., Afuang, L. E. & Gee, G. V. A. 2002 Philippine amphibians and reptiles. In *Philippine biodiversity conservation priorities: a second iteration of the national biodiversity strategy and action plan* (eds P. S. Ong, L. E. Afuang & R. G. Rosell-Ambal), pp. 26–44. Quezon City, Philippines: Department of the Environment and Natural Resources-Protected Areas and Wildlife Bureau, Conservation International Philippines, Biodiversity Conservation Program-University of the Philippines Center for Integrative and Developmental Studies, and Foundation for the Philippine Environment.
- Frost, D. R. 2009 *Amphibian species of the world: an online reference*, version 5.3. New York, NY: American Museum of Natural History. See [research.amnh.org/herpetology/amphibia/index.html](http://research.amnh.org/herpetology/amphibia/index.html) (date last accessed 1 October 2009).
- Iskandar, D. & Mumpuni 2004 *Philautus jacobsoni*. In IUCN 2009. IUCN Red List of Threatened Species, version 2009.1. See <http://www.iucnredlist.org> (date last accessed 22 June 2009).
- IUCN 2009 *IUCN Red List of Threatened Species*, version 2009.1. See [www.iucnredlist.org](http://www.iucnredlist.org) (date last accessed 1 May 2009).
- Kusrini, M. D., Skerratt, L. F., Garland, S., Berger, L. & Endarwin, W. 2008 Chytridiomycosis in frogs of Mount Gede Pangrango, Indonesia. *Dis. Aquat. Organ.* **82**, 187–194. (doi:10.3354/dao01981)
- McLeod, D. S., Sheridan, J. A., Jiraungkoorskul, W. & Khonsue, W. 2008 A survey for the chytrid fungus in Thai amphibians. *Raff. Bull. Zool.* **56**, 199–204.
- Rowley, J. J. L., Chan, S. K. F., Tang, W. S., Speare, R., Skerratt, L. F., Alford, R. A., Cheung, K. S., Ho, C. Y. & Campbell, R. 2007 Survey for the amphibian chytrid *Batrachochytrium dendrobatidis* in Hong Kong in native amphibians and in the international amphibian trade. *Dis. Aquat. Organ.* **78**, 87–95. (doi:10.3354/dao01861)
- Sodhi, N. S., Koh, L. P., Brook, B. W. & Ng, P. K. L. 2004 Southeast Asian biodiversity: an impending disaster. *Trends Ecol. Evol.* **19**, 654–660. (doi:10.1016/j.tree.2004.09.006)
- Stuart, S. N., Chanson, J. S., Cox, N. A., Young, B. E., Rodrigues, A. S. L., Fischman, D. L. & Waller, R. W. 2004 Status and trends of amphibian declines and extinctions worldwide. *Science* **306**, 1783–1786. (doi:10.1126/science.1103538)
- Stuart, B. L., Inger, R. F. & Voris, H. K. 2006a High level of cryptic species diversity revealed by sympatric lineages of Southeast Asian forest frogs. *Biol. Lett.* **2**, 470–474. (doi:10.1098/rsbl.2006.0505)
- Stuart, B. L., Rhodin, A. G., Grismer, L. L. & Hansel, T. 2006b Scientific description can imperil species. *Science* **312**, 1137. (doi:10.1126/science.312.5777.1137b)
- Weisrock, D. W., Papenfuss, T. J., Macey, J. R., Litvinchul, S. N., Polymeni, R., Ugurtas, I. H., Zhao, E., Jowkar, H. & Larson, A. 2006 A molecular assessment of phylogenetic relationships and lineage accumulation rates within the family Salamandridae (Amphibia, Caudata). *Mol. Phylogenet. Evol.* **41**, 368–383. (doi:10.1016/j.ympev.2006.05.008)
- Zheng, Y. C., Li, S. & Fu, J. 2008 A phylogenetic analysis of the frog genera *Vibrissaphora* and *Leptobrachium*, and the correlated evolution of nuptial spine and reversed sexual size dimorphism. *Mol. Phylogenet. Evol.* **46**, 695–707. (doi:10.1016/j.ympev.2007.09.019)
- Achard, F., Eva, H. D., Stibig, H.-J., Mayaux, P., Gallego, J., Richards, T. & Malingreau, P. 2002 Determination of deforestation rates of the world's humid tropical forests. *Science* **297**, 999–1002. (doi:10.1126/science.1070656)
- Bain, R. H. & Hurley, M. M. 2004 Towards an understanding of the biogeography of the herpetofauna of Indochina. In *19th Meeting of the Int. Congress of Zoology (Contributed paper)*, Beijing, China, August 2004.
- Bain, R. H., Lathrop, A., Murphy, R. W., Orlov, N. L. & Ho, C. T. 2003 Cryptic species of a cascade frog from Southeast Asia: taxonomic revisions and descriptions of six new species. *Am. Mus. Novit.* **3417**, 1–60. (doi:10.1206/0003-0082(2003)417<0001:CSOACF>2.0.CO;2)
- Bain, R. H., Nguyen, Q. T. & Doan, V. K. 2007 New herpetofaunal records from Vietnam. *Herpetol. Rev.* **38**, 107–117.
- Bickford, D., Iskandar, D. T. & Barlian, A. 2008 A lungless frog discovered on Borneo. *Curr. Biol.* **18**, 374–375. (doi:10.1016/j.cub.2008.03.010)
- Brown, R. M. & Diesmos, A. C. 2009 Philippines, biology. In *Encyclopedia of islands* (eds R. Gillespie & D. Clague),